6-2 Appraisal:

Field appraisal is the post-discovery evaluation of a potential development opportunity. The most important questions for a company, having discovered oil or gas, are about the discovery size and its commercial viability. The appraisal phase aims to answers these questions by drilling wells that help define the reservoir limit and understand the variation in well-productivity across the reservoir. Extensive analysis of data gathered from drilling, logging, coring, sampling, and testing reduces uncertainty in the size of the oil or gas reservoir, its properties, and production rates.

Any geologic complexities involved may also be brought to light at this stage. A reservoir located in a complex geologic setting (Fig.4), including layering, faults, fractures, barriers, and facies change, usually requires the drilling of quite a number of wells and multi-studies for detailed characterization. Any uncertainty related to the reservoir geometry and characteristics diminishes to a large extent as more wells are drilled.

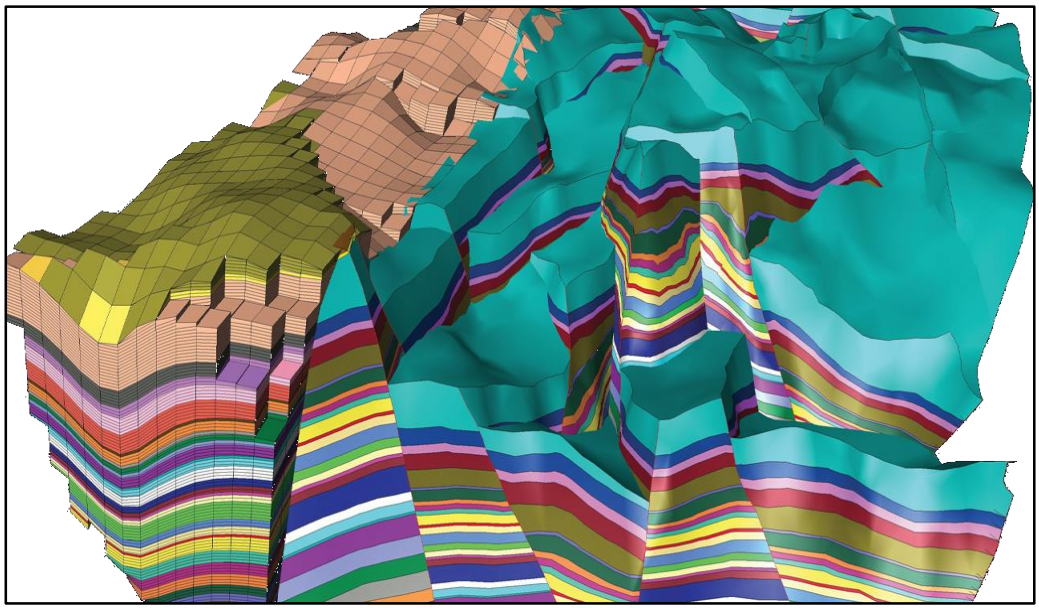


Fig.4 Geological complexities

Drilling engineers, petrophysicists, and reservoir engineers are again involved. Additional data on reservoir continuity and variations in pay thickness, porosity, oil saturation, and reservoir pressure are collected. Depending on reservoir complexity, one or more wells are cored, which are analyzed in the laboratory for porosity, absolute permeability, relative permeability, and spectrographic characteristics. Oil, gas, and water properties, such as gas solubility, formation volume factor, compressibility, and viscosity, are determined by analyzing the reservoir fluid samples.

This phase is characterized by high uncertainty and capital investment, significantly reduced by the successful drilling of appraisal wells, data acquisition, and testing. By the end of this phase, the Field Development team is comfortable with a reasonable assessment of hydrocarbons' volume, production potential, and commerciality. The new reservoir model helps design a ***conceptual development plan (CDP)*** that includes an in-depth analysis of various development options.

6-3 Development:

The development phase starts after the appraisal phase is over and before the onset of the production phase. Development strategy of the reservoir and drilling of the future wells are based on reservoir simulation studies that run large numbers of what-if scenarios in terms of reservoir uncertainties, well locations, and design. The most appropriate strategy is adopted to develop the field.

The new wells generate enormous subsurface and production data that validate the reservoir model configuration and provide assurance for performance forecasting. The development team is now more confident of its in-place estimates and reserves calculations. It can now design an evidence-based Field Development Plan (FDP) with longterm production forecasts to support the business strategy and

goals. *Depending on the field's size and resources at the company's disposal, the development phase can last 5 to 7 years, or even longer*.

Ideally speaking, this phase aims to deliver the plateau rate of oil/gas production without interruption as the field transits from the development to the production phase. There is a significant reduction in uncertainty by this time and, therefore, a lower risk to investments.

6-4 Production:

The production phase marks the first commercial production of oil and gas from the subsurface via production wells drilled. It also marks a turning point in an oil/gas field's lifecycle when the investment curve shifts from expenditure to earnings.

Reservoir production overlaps development as existing wells are produced while new wells are being drilled as per the reservoir development schedule. Production usually occurs in multiple stages. The stages of production are based on primary, secondary, and enhanced oil recovery (EOR) processes.

- **Primary production** of oil or gas reservoir is obtained at the expense of the natural reservoir energy. There are multiple sources of natural energy, including rock and fluid expansion (this mechanism has a very low recovery efficiency and typically accounts for less than five percent), liberation of dissolved gas, water influx from adjacent aquifers, and gravity.
- **Secondary recovery** from oil reservoirs is accomplished by injecting fluids to augment natural energy. Secondary recovery is based on waterflooding, gas injection, or gas–water combination floods.
- **EOR processes** include thermal, chemical, and miscible floods. These are employed by using an external source of energy to recover oil that cannot be produced economically by conventional primary and secondary means.

Table 1: Production of conventional oil reservoirs

Reservoir production	Typical recovery (%)	Notes
Primary	20–20	Production by natural drive mechanisms
Secondary	15–25	Mostly waterflood and gas injection
Tertiary	5–15	EOR methods

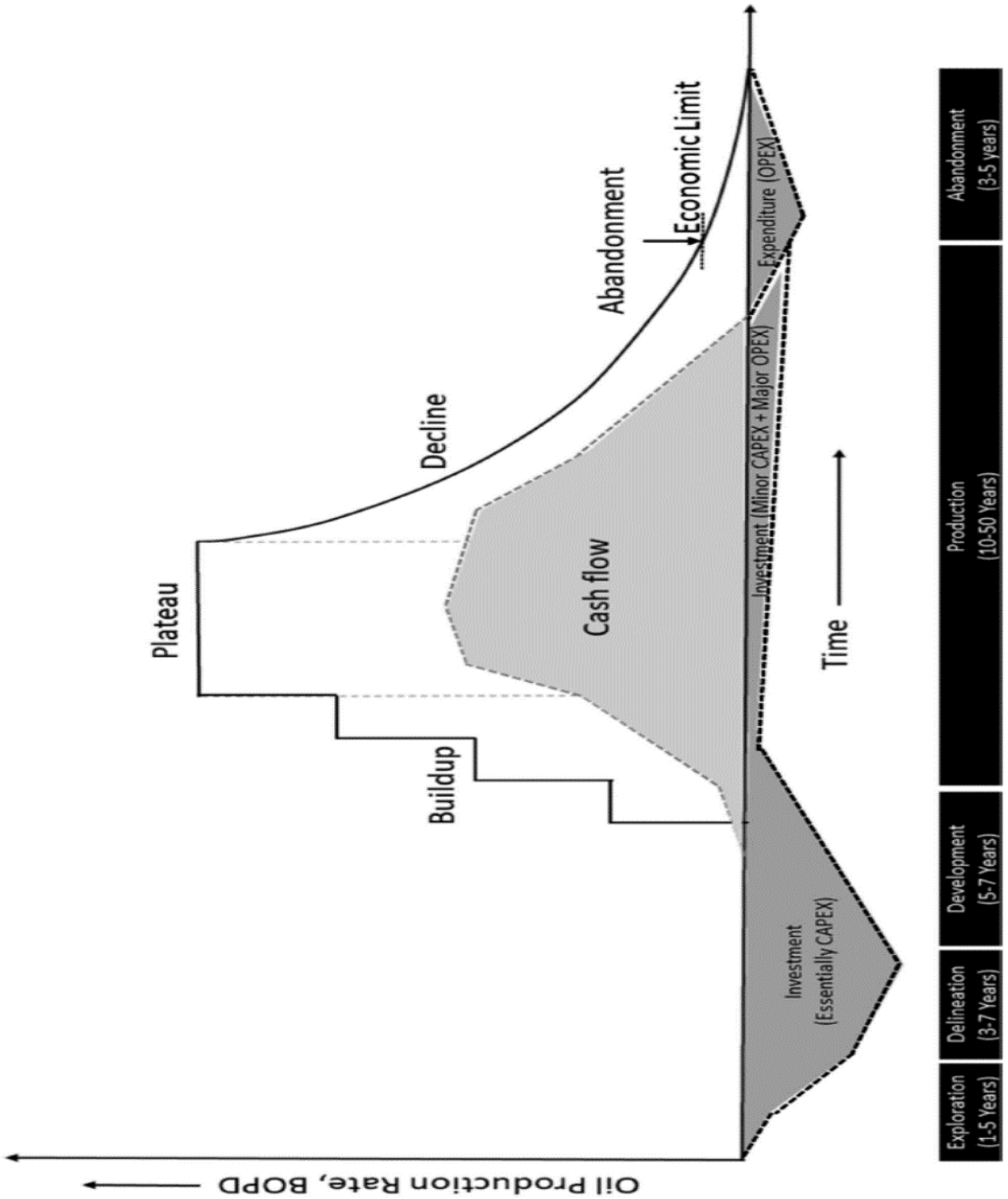
6-5 Abandonment:

Abandonment is the terminal phase in the lifetime of an oilfield characterized by an economic limit. ***The economic limit*** *is described by the low production rate when it is no longer economical to continue production because operating costs are higher than the net income.*

Well production rate, reservoir location (onshore vs. offshore), operating costs, market conditions, environmental and other regulations, and other factors may play a critical role in abandoning a reservoir. The abandonment process requires removing the tubing from the well and plugging of hydrocarbon-bearing sections of the well with cement to prevent any potential leak/communication with the aquifers. All surface equipment is removed, and the casing pipe is cut below the surface before relinquishing the field. A sturdy steel cap is then welded on top of the well.

The main reasons for abandonment:

- Declining oil and gas production rates, which are not economically sustainable
- Excessive water–oil ratio (WOR) or gas–oil ratio (GOR) at producing wells.
- IOR efforts do not recover the remaining oil economically.
- Cost of operation and maintenance is excessive with unfavorable rate of return on investment.



Significance of Production in the Lifecycle of an Oil and Gas Reservoir